US-LARP meeting 16-9-2003

Initial Beam Instrumentation, HS

- CERN meeting on instrumentation (week 4/03)
- « reduction « to 3 initial instruments plus
  « additional « instrumentation
  - tune and chromaticity control
  - luminosity measurments
  - LDM
- CERN ideas for FY 2004
- Complementary resources from ESGARD
- Organisational issues

US-LARP Table version march 2003

Instrument system	*US liaison*	*BNL*	*FNAL*	*LBNL*	*Test bed*	*CERN liaison*	*Acc Phys*	*CR Sys Comm*	*Priority*	*Scope* [12]	
Luminosity monitor	Turner	~~-/Y~~		Y	~~-/BNL~~	Bravin	Y	Y	1		[3]
Longitudinal density monitor ~~(laser/diode array)~~	Turner			Y		Hutchins	Y		1		[6]
~~Bunch-by-bunch closed orbit correction~~	~~Turner~~			~~Y~~							[1]
~~Remote operations~~				~~Y~~			~~Y~~				[2]
Remote maintenance	Agarwall? / Peggs			Y		Schmickler			1		[11]
Beam-beam compensation (electron lens/wires)	Shiltsev		Y		FNAL	Koutchouk			3		[4]
~~Ramp beam~~ Dynamic Q/Q' measurement & feedback	Cameron / Marriner	Y	Y	(Y)	BNL FNAL	Jones	Y	Y	2		[5]
Schottky monitors	Vetter(BNL) / *Byrd*	Y		Y	BNL	Caspers			3		
Electron cloud	Gassner / *Byrd*	Y		Y	FNAL?	*Hilleret, Jimenez*	Y		?		[10]
~~Head-tail monitor~~	~~Dawson~~	~~Y~~			~~BNL~~	~~Catalan-Lasheras~~					[8]
~~Ionization Profile Monitor~~	~~Connolly~~	~~Y~~	~~?~~	~~?~~	~~?~~			~~Y~~			[9]
AC Dipole	*BNL*	Y				Schmickler	Y	?	2		[7]

Notes

[1] Can be done by the beam-beam compensator wire, per JPK

[2] Remains in accelerator physics

[3] The BNL piece - testing CdTe in RHIC - already exists and is outside LARP

[4] Clearly has a strong AP component

[5] For the moment this is only an exchange of ideas with no hdw deliverable

[6] How do we decide on the diode array vs laser mixing scheme?

[7] "Not really an instrument, but not really a magnet" --Peggs

[8] Subset of Q/Q' meas

[9] non-LARP collaboration and exchange of info. Needed for ion running => could be NP money for this

[10] Not yet clear what is desired from CERN - activity in CERN Vac Gp, who is not here

[11] specs and guidelines and facilities for remote maintenance of US LARP instruments

[12] To be filled in via the exchange of drafts of the DOE proposal

Changes brought in for DOE proposal

- Remote maintenance assembled with commisioning/GAN activity
- Dynamic Q/Q' control lifted to priority 1
  -> this needs further discussion:
  1) Large overlap with accelerator physics
  2) What are reasonable deliverables outside the existing BNL-CERN collaboration agreement?

Plans & commissioning for the PLL-based LHC tune tracking system

Maria Elena Angoletta

on behalf of CERN AB/ BDI team

US-LARP meeting

FNAL, 9 May 2003

Topics

1. Tune & chromaticity requirements
2. Tune measurements
3. Chromaticity measurements
3. Commissioning day 1
4. Commissioning day 1 + 1
5. Commissioning day N

Tune & Chromaticity requirements

Tolerances on the beam parameters

[BI Specification Team LHC-BSRL-ES-0001]

- dQ =< (Qx-Qy)/10 $\Rightarrow$ .003 at injection
  .001 in collision
- dQ' =< ±1 at injection (transverse stability)
  ± 3 at 7 TeV (contribution to tune spread)

Expected time scales for variations (worst cases)

[BI Specification Team LHC-BSRL-ES-0001]

- Snap-back: dQ <= 0.0008 per second over up to 60 seconds
  dQ'<= 2.7 per second over up to 60 seconds

Feedback *probably* required on both tune and chromaticity (see *Day N*).

Tune Measurement

Methods for feed-forward:

Beam excitation	Comments
Single kick	Uses pulsed kicker magnet. Damped oscillation from initial large amplitude Precision depends on damping time
Random noise kicks	Injected into transverse feedback loop. Useful for broad-band spectral analysis. Precision 10^{-3} - 10^{-4}
Sine wave frequency sweep ("chirp")	Synchronous detection of beam motion ⇒ full beam transfer function (amplitude and phase). Precision typically 10^{-4}, limited by beam stability and measurement time.
Sine wave at fractional tune frequency	PLL keeps exciter on tune (at low amplitude) Best for tracking tune changes. Precision ~ 10^{-5}, for PLL BW 1-10 Hz
Sine wave at frequency outside tune spread	So-called "AC-dipole" method. Excitation ramped up and down adiabatically. "No" emittance blowup.

Physics beam measurements more delicate:

- limited BDI ε blowup budget (~2%)
- active transverse damping (t_d ~ 50 turns)

Chromaticity measurements

1. Tune difference for different beam momenta.	Used at HERA, LEP & RHIC in combination with PLL tune tracking.
2. Width of tune peak or damping time.	Model-dependent, non linear effects. Used at DESY.
3. Amplitude ratio of synchrotron sidebands.	Difficult to exploit in hadron machines with low synchrotron tune.
4. Excitation of energy oscillations & PLL tune tracking.	First promising steps at SPS.
5. Bunch spectrum variations during betatron oscillations.	Difficult to measure.
6. Head-tail phase advance (same as 5 but in time domain).	Very good results. Requires kick stimulus $\rightarrow$ ε growth.

Commissioning – Day 1

Beam: 1 pilot ($5 \cdot 10^9$ p/bunch).

Excitation: single kick.

Detector:

- **BPM**: 500 button monitors/ring, both transverse planes
  - FFTs gives good tune accuracy.
  - Phase information ➔ integer part of Q.
  - BUT, 1 bit ~ 20 μm ➔ will need ~mm kicks (➔ ε blowup).
- **Tune couplers**: 15mm stripline couplers
  - more sensitive than 500 BPMs for sub-mm oscillations (but still ε blowup).

Q' :

- from FFT measurement with different Δp *or*
- from head-tail monitor after kick.

Commissioning – Day 1 + 1

Beam: several bunches ($5 \cdot 10^9$ … $5 \cdot 10^{10}$ p/bunch)

Excitation: turn-by-turn kicks

- small stripline coupler;
- transverse feedback kicker.

Detector: as before + **Resonant BPM.**

- Sensitive to small beam excitations ➔ little ε blowup
- Can be used as part of a PLL system & for feedback.

PLL tune-tracking without tune feedback.

i.e. feedforward of "tune history" to next ramp, squeeze…

Q' : from Δp modulation
- a) below $q_S/5$
- b) above $5q_S$

Commissioning – Day N

Beam: ~ 3000 bunches up to $10 \cdot 10^{11}$ p/bunch.

Excitation: as *Day 1+1* but bunch excitation compatible with transverse resistive damping.

Detector: as before.

Decision on feedback when machine reproducibility & *real* machine parameters are known.

My Conclusions on Q,Q'

- Not the most important item for FY2004
- Needs: Modelling of BTF; fundamental understanding of beam spectra, choice of position sensor
- In addition: existing BNL-CERN collaboration will continue on this subject

Luminosity Monitors

- 2 technologies fully developed:
- LBL: ionization chambers
  + radiation hardness can be assumed
  - 40 Mhz bandwidth to be shown
- CERN-LETI: CdTe detectors
  + bandwidth has been shown
  - radiation hardness and linked to this production cost are problematic
- Need for FY2004: (Beam) Tests to make technology choice.

Longitudinal density monitor (1/2)

- Progress during 2003 suffered from work at LBL on the luminosity monitors and from the intensive preparations of a beam test at FNAL. (see cartoon of S.Hutchins)
- LDM essential for early days of LHC; has to get highest priority now

Longitudinal density monitor (2/2)

- Needs in FY2004:
- Full design of laser system for LHC parameters (photon flux, crystal conversion efficiency...)
  comparison of system with specs.
- In case of non-compliance (S.Hutchins anticipated a factor 100...1000 missing) alternative design based on APDs

Complementary resources from ESGARD

- HEHIHB activity within ESGARD
- Some 150 kEuros « networking » money obtained (over 5 years)
- Money has to be spent exclusively on communication/knowledge exchange events
- Lum, LDM, Q,Q' are part of the « ABI workpackages »
- US-LARP can save money on travel cost

Organisational issues

- Good experience with so called « task sheets » during CERN-TRIUMF collaboation
- Regular review of task progress during meetings. Written minutes of collaboration meetings.
- Scheduling of collaboration meetings well in advance
- Communication, communication....